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6 March 2009

Stan Perry, Esquire
Haynes Boone LLP
One Houston Center
1221 McKinney Street, Suite 2100
Houston, TX 77010-2007

Re: Rebuttal Report
Ben Brown v Shell Oil
EPI Project # 29013

Dear Mr. Perry:

This rebuttal report summarizes my opinions regarding the methodology, assumptions, and resources used by the plaintiff's experts, Dr. Mark Nicas and Dr. Melvyn Kopstein in their assessment of the plaintiff, Ben Brown's, potential benzene exposures. Mr. Brown was reportedly diagnosed with multiple myeloma on 3 February 2007[1].

I am qualified to provide opinions in this case due to my experience of more than 32 years as an industrial hygienist. Currently, I am President of Environmental Profiles, Inc. (EPI) in Baltimore, Maryland. Formerly, I was with the National Institute for Occupational Safety and Health and led a group of industrial hygienists conducting research for the National Occupational Exposure Survey. As an industrial hygienist for the United States Coast Guard, I conducted thousands of exposure assessments of a wide range of products, including numerous benzene-containing materials. My responsibilities also included the management of the occupational medical monitoring program for the 5th Coast Guard District. I was President of the Chesapeake Section of the American Industrial Hygiene Association (AIHA) and was a member of the national AIHA Product Health and Safety Committee and the Emergency Response Planning Committee. I have also authored the *Health and Safety Audits Manual*, published by Government Institutes, and the *AIHA Hazard Communication Guide*, published by the AIHA. The American Board of Industrial Hygiene certifies me as an industrial hygienist and the Board of Certified Safety Professionals certifies me as a safety professional. My curriculum vitae is attached as Attachment I and my four-year history of testimony is attached as Attachment II. Environmental Profiles, Inc. charges $285 per hour plus expense for my time in preparation and testimony in this matter.

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[1] Complaint

Plaintiff's Methodology, Assumptions and Resources

Dr. Mark Nicas's estimation of Mr. Brown's 8-hour Time-Weighted Average (TWA) daily exposure to benzene from paraffin cutting at well heads is neither relevant nor reliable for the following reasons:

- He used inappropriate air monitoring data to be representative of Mr. Brown's airborne exposure,
- He used a mathematical input variables model for the dermal exposure calculation, that has not been validated,
- He utilized a skin absorption value in the model that was based on pure benzene and not a hydrocarbon mixture,
- He inappropriately added this dermal equivalent value to his inhalation value and compared this combined value to the airborne Occupational Safety and Health (OSHA) Permissible Exposure Limit (PEL) for benzene and the airborne American Conference for Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLV) for benzene.

Dr. Nicas's estimation of Mr. Brown's potential short-term exposure to benzene from the cleaning up of oil spills is neither relevant nor reliable for the following reasons:

- He provided no basis to assume that 1% of the benzene would evaporate rapidly from the crude oil spill.
- He described a fixed environment (air space around Mr. Brown) that does not represent Mr. Brown's outdoor work environment and
- He did not account for the substantial dilution ventilation or air flow through the breathing zone or the air space around Mr. Brown on an off-shore platform.

Dr. Kopstein's opinion that Mr. Brown was excessively exposed to benzene was based on two key documents. These documents cite tasks and environments that are not representative of Mr. Brown's work environment or work tasks, and therefore do not support his opinion.

Dr. Kopstein's reliance on odor threshold for determining Mr. Brown's airborne exposure to benzene is not an accepted industrial hygiene practice nor is it a reliable method to predict the air concentration with any degree of certainty, especially in a mixed hydrocarbon.

Background

The industrial hygiene data provided to date was not specific to Mr. Brown's job tasks but is more generic in nature. Mr. Brown provided testimony regarding his job duties and tasks while he was a maintenance trainee, maintenance man, and lease operator. However, Mr. Brown did not provide information regarding the products he used to accomplish some of these required tasks. He referred to the use of solvents to clean up platforms, tools, remove paraffin from wells, and even clean his hands and arms. Mr. Brown never identified the types of solvents used to accomplish these tasks. He did identify one solvent as naphtha, that was stored on the platforms in drums. When Mr. Brown was asked about the solvent he used to clean himself with after cleaning a test vessel, he responded, "I only knew of one kind out there. A solvent is a solvent, you know."[2] Information regarding the products used by Mr. Brown is critical in order to accurately assess occupational exposures. This rebuttal report describes appropriate exposure methodologies and details as to how Drs. Nicas and Kopstein's failure to follow this methodology renders their opinions regarding Mr. Brown's alleged benzene exposure neither relevant nor scientifically reliable.

Exposure Assessment Methodology

Comprehensive exposure assessment is the systematic review of the processes, practices, materials, and division of labor present in a workplace that is used to define and judge exposures (Mulhausen and Damiano 1997). In other words, an exposure assessment describes the magnitude (concentration), frequency, and duration of a person's exposure and involves the integration of the work process and environment, the work tasks, the personal protective equipment, and the properties of the chemical or physical agents. The following basic tools are used to conduct an exposure assessment:

1. a characterization of the environment in which the exposure occurred (including room size and ventilation rate);
2. a characterization of the job and tasks conducted in that environment (including frequency and duration of exposures);
3. a characterization of the products (including volatility);
4. a review and analysis of historical exposure data collected during tasks involving the appropriate handling of the product;
5. evaluation of exposure data to determine whether accepted air sampling and analytical techniques and/or modeling were used to assess the magnitude of exposures; and,

[2] Deposition of Ben Brown taken 7 January 2009, page 77

6. a characterization of the relevant safety and health regulations and the associated exposure limits.

The industrial hygienist's training, skills, and experience qualifies him or her to direct efforts for collecting critical information for basic characterization, designating similar exposure groups, and identifying important occupational exposures (Ignacio and Bullock 2006).

Because it is difficult to measure exposures to every worker, the strategy employed by industrial hygienists is to assemble workers believed to have similar exposures into a similar exposure group (SEG). A SEG is a group of workers having the same general exposure characteristics because of similarities and frequency of the tasks they perform, the materials, and processes with which they work, and the similarity of the way they perform the tasks (Ignacio and Bullock 2006).

Air monitoring for determination of employee exposure is presently the standard method for evaluating exposures for purposes of comparison with occupational health standards. However, no sampling data for Mr. Brown is available. Therefore, in order to assess Mr. Brown's benzene exposure, the industrial hygienist may use exposure data available in the published literature of workers having similar exposures to Mr. Brown or exposure assessment models can be used to retrospectively evaluate his potential exposures.

Retrospective Exposure Assessment

Retrospective (Historic) Exposure Assessment is Part of Industrial Hygiene Practice

- Retrospective exposure assessment and individual dose reconstruction are tools that have been used by industrial hygienists, epidemiologists, and other health professionals for many years, and are a part of the traditional exposure assessment process.[3,4,5,6]
- Exposure assessments and retrospective exposure assessments are methods upon which industrial hygienists and other trained experts routinely rely. Industrial hygienists contribute to the development of the information necessary to reconstruct historical exposure dose.

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3 Esmen N.A. "Retrospective Industrial Hygiene Surveys" Am. Ind. Hyg. Assoc. J. 40 (1979): 58-65.

4 Checkaway et al., Industrial Hygiene Involvement in Occupational Epidemiology, Am. Ind. Hyg. Assoc. J. 48 (1987) 515-523.

5 Mona Baumgarten, J. Siemiatycki, G. Gibbs, Validity of Work Histories Obtained by Interview for Epidemiologic Purposes, Am. J. Epidem. 118 (4) 1983.

6 Denis Hemon, et al. Retrospective Evaluation of Occupational Exposures in Cancer Epidemiology: A European Concerted Action of Research, Appl. Occup. Environ. Hyg. 6 (6) 1991.

Retrospective exposure assessments are useful tools to calculate historic exposures only when the methods employed are standardized and validated, and factors used in the estimates are truly representative of the historic products, work practices, and environmental conditions.

Exposure assessments can consider multiple routes of exposure: inhalation, dermal, and ingestion. OSHA and NIOSH have published standard methods to measure many different solvents in the air. Sampling and analytical error rates have been measured and are reported for each of these methods.[7] Standard methods for air sampling and analysis are published, readily available, and widely used.[8] By contrast to air monitoring, the assessment of dermal exposures and dermal dose are not relevant, reliable, or consistent with standard industrial hygiene practice. According to OSHA:

> "In comparison to air sampling and even biological monitoring, dermal dosimetry is not a simple or routine procedure. Thus far, its use is limited to research and to specially designed studies. An individual applying dermal dosimeters should be thoroughly trained regarding the placement and retrieval of the dosimeters and recording of observations and other information about the activity. In addition to objective parameters, observed work practices can also have statistically significant important influences on dermal exposure, as observed by Popendorf."[9]

Dermal Exposure Assessment

Dermal Exposure Assessment is not a standard Industrial Hygiene method for quantifying exposures for comparison with Occupational Exposure Limits.

- The tools and the input variables to quantify dermal exposure to organic solvents such as benzene have not been standardized nor validated and remain in development.[10,11] Quantitative dermal exposure assessment is not standard practice for industrial hygienists for comparison with occupational health standards and guidelines.
- The dermal estimate relied upon by the plaintiff's exposure assessment expert is based on the penetration rate for a solvent through a person's skin (flux). Flux

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7 NIOSH Manual of Analytic Methods is available at http://www.cdc.gov/niosh/nmam/ and includes validated sampling and analytical methods. OSHA validated sampling and analytical methods are available at http://www.osha.gov/dts/sltc/methods/index.html. Information regarding limit of detection, range, and precision; i.e. sampling and analytical error is provided for validated NIOSH and OSHA methods.

8 ibid.

9 OSHA. "Dermal Dosimetry" http://www.osha.gov/SLTC/dermalexposure/dosimetry.html

10 Fiserova-Bergerova V. "Letter to the Editor: RE: Response to Bunge's Letter to the Editor." American Journal of Industrial Medicine 34 (1998): 91.

11 Jakasa I and Kezic S. "Evaluation of in-vivo animal and in-vitro models for prediction of dermal absorption in man." Human & Experimental Toxicology 27 (2008): 281-288.

values for benzene (100% or neat) have no known error rate. The issue is further complicated, because the flux value for a solvent in a product mixture is highly dependent on what other materials are in the mixture, at what relative percentages, and numerous environmental factors (air speed across the surface, temperature, etc).

- The Occupational Safety and Health Administration (OSHA), National Institute for Occupational Safety and Health (NIOSH), and the American Conference of Governmental Industrial Hygienists (ACGIH) considered dermal routes of exposure in the development of the Benzene standard. After addressing dermal exposures in the development of occupational exposure limits for benzene, OSHA set an airborne exposure limit. Rather than add the results of dermal exposure models to measured airborne exposures (acquired through validated, standardized methods), OSHA relied upon airborne concentrations derived from epidemiological studies in order to evaluate workplace exposures to benzene and benzene-containing solvents.

- There is no dermal exposure limit for benzene. A separate dose calculation was not added to the inhalation dose when developing the occupational health standards, i.e., OSHA Permissible Exposure Limit (PEL), ACGIH Threshold Limit Values (TLV®) and the NIOSH Recommended Exposure Limits (REL).

In light of these uncertainties and issues, OSHA, ACGIH, and NIOSH neither require nor recommend quantifying dermal exposures.

Dermal Flux Models have not been validated for solvent mixtures and are therefore unreliable

Uncertainties in dermal exposure models include the selection of input values for flux (the rate of movement of a substance through the skin), and other individual specific values such as surface area exposed, exposure duration and exposure frequency. For example, flux is impacted by the percentage of benzene in the mixture (reformate and crude oil contain a mixture of multiple chemicals); and the presence and type of co-solvents (e.g. aromatics, alcohols, aliphatics or water).

One of the major sources of variability in a dermal exposure model is the percentage of a chemical in a mixture and the other characteristics of the other chemicals in the mixture. The flux values for pure (neat) benzene from four studies varied from 0.1 to 1.85 mg/cm^2-hour (an 18 fold variation). This shows the variability in experimentally derived flux values for pure benzene. For benzene in solvent mixtures such as gasoline, the measured flux values ranged from 0.00271 to 0.0626 mg/cm^2-hour for gasoline containing 0.39% to 5% benzene, a 23-fold difference. Additional studies demonstrate the significant variability in

determining the flux value for benzene in hydrocarbon mixtures.[12,13,14,15,16] See Table I. (Attachment III).

Many of the dermal exposure studies have "employed compounds applied to the skin in aqueous or single solvent systems, a dosing scenario that does not mimic occupational, environmental or pharmaceutical exposure where compounds are often exposed with associated solvents, contaminants or specific formulation additives. It is well known that such factors modulate absorption of compounds".[17]

Fiserova-Bergerova (1993) explained that when inhalation is not the primary route of exposure for solvents, the lungs will aid in the excretion of the absorbed solvent. This represents another factor that has not yet been addressed in dermal flux models and is among the reasons why biological monitoring is more representative of total absorbed dose estimates of the amount absorbed into the body.

> "Dermal absorption is affected by other routes of entry of the chemical into the body. The role of the lungs in the exposure to volatile chemicals deserves special attention. Dermal absorption increases the concentration in venous blood. Consequently, pulmonary uptake is reduced or is replaced by elimination." "Extensive pulmonary clearance of volatile chemicals reduces their potential for dermal toxicity."

If the concentration of the mixed venous blood is greater than the concentration of the arterial blood, then pulmonary wash out occurs. The pulmonary wash-out was documented experimentally for methanol and xylene.[18]

Dermal modeling applied for purposes of calculating exposure dose is not a standardized or accepted industrial hygiene method for evaluating an individual's exposures to volatile mixtures such as reformate or benzene for comparison with established occupational health standards. The degree of uncertainty associated with these models varies widely depending

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12 Adami, et al. "Penetration of benzene, toluene and xylenes contained in gasolines through human abdominal skin in vitro." Toxicology in Vitro 20-8 (2006): 1321-1230.

13 Blank and McAuliffe, 1985.

14 Franz, TJ. Chapter 5 "Percutaneous Absorption of Benzene." In Advances in Modern Environmental Toxicology. Volume VI – Applied Toxicology of Petroleum Hydrocarbons. Editors: MacFarland, Holdsworth, MacGregor, Call, and Lane. Princeton Scientific Publications, Inc. 1984: 61-70.

15 Hanke et al. 1961.

16 Loden, 1986.

17 Riviere, JE and Brooks, JD. "Prediction of dermal absorption from complex chemical mixtures: incorporation of vehicle effects and interactions into a QSPR framework." SAR and QSAR in Environmental Research, 18 (2007):1, 31 — 44.

18 Fiserova-Bergerova V. "Relevance of occupational skin exposure." Annals of Occupational Hygiene 37 (1993): 673-685. p. 677

on the input values used to estimate the flux, the use of a dynamic flux value for the specific material being evaluated and other exposure factor estimates.[19]

Specific Reasons for this Lack of Reliability are:

(1) The process for modeling dermal exposures has not been validated and there is no reproducible measure of its precision or accuracy. Dermal dose model calculations have no known error rate for pure benzene or benzene-containing solvent mixtures;

(2) Flux estimates for benzene have no known error rate, no known reliability, and no known reproducibility;

(3) Dermal flux models are particularly unreliable when evaluating solvent mixtures because the skin barriers do not behave in the same way to a neat (100%) benzene product, as they do to benzene-containing solvent mixtures; and

(4) Methods, in development to quantify exposures via the dermal route of exposure, rely on direct measurement of the chemical of concern or other internal markers of exposure measured in blood or urine utilizing validated methods.

The rate of absorption can be dramatically impacted by the volatility of the various components of the mixture. Franz stated, "further work is needed …to define the role of vehicle (solvents or mixtures other than pure benzene) in controlling percutaneous absorption of benzene."[20] Bowman and Maibach (2000) commented, "Industrial exposure is also often to mixtures and seldom to the neat compound or solvent. If one or several compounds are volatile, evaporative loss of one or several of these can dramatically change the absorption of the others as their relative concentrations are increased. Many organic solvents have a high vapor pressure and can be expected to have a substantial loss through evaporation when non- occluded skin is exposed."[21] For all the reasons noted in this section, benzene occupational health standards and guidelines are not based on dermal dose calculations.

Plaintiff's Expert Mark Nicas Report

According to Dr. Mark Nicas's discussion with the plaintiff, the plaintiff, for a period of one to one and one half years was involved in the removing of paraffin build-up in the well heads. Mr. Brown operated a self-propelled, self-elevating barge that operated

19 OSHA Preamble to the Benzene Standard. Federal Register 52(176): September 11, 1987; pp. 34487-34505.

20 Franz, p. 70.

21 Bowman and Maibach 2000; pages 131, 133.

cutting tools that ran down into the well pipe. He told Dr. Nicas that "The barge crane lifted a tubular lubricator, the bottom of which was attached to the well head. A winch on the barge deck let out and reeled back a wire line equipped with cutting tools at its end. The wire line was lowered down through the lubricator and into the well piping. The cutting tool had a set of knives that removed the paraffin adhering to the interior pipe walls. Paraffin cutting often employed a solvent that was pumped from a 55-gallon barrel on the barge deck into the well piping." The solvent was pumped up to the top of the lubricator, and down through the lubricator into the well pipe.

Dr. Nicas attempted to quantify Mr. Brown's 8-hour Time-weighted average (TWA) daily exposure to benzene from the use of Shell Oil Company Reformate during this paraffin cutting at well heads located on satellite well platforms in Block 24. His approach to quantifying Mr. Brown's historical exposure to benzene from Shell Oil Company Reformate was based on two routes of exposure: inhalation and dermal routes.

Inhalation Dose

For the inhalation exposure, Dr. Nicas utilized three long-term air monitoring data values taken on laboratory workers conducting "routine duties in reformate lab" to estimate the airborne concentration that Mr. Brown was exposed to while performing the paraffin removal. As previously noted a SEG is "A group of workers having the same general exposure profile for an agent because of the similarity and frequency of the task(s) they perform, the similarity of the materials and processes with which they work, and the similarity of the way they perform the task(s)."

In lieu of having personal monitoring data on Mr. Brown, personal monitoring data on another worker meeting the SEG criteria could have been used by the plaintiff's industrial hygiene expert to estimate Mr. Brown's exposure concentration. However in this case, the tasks performed and processes associated with Mr. Brown were in no way similar to the tasks and processes from which the plaintiff's expert derived the air monitoring data. The air monitoring data obtained from the laboratory workers was not relevant to Mr. Brown's airborne exposure while performing his duties on the well head. Importantly the environmental conditions, such as wind direction and speed (several hundred feet per minute), of Mr. Brown's outdoor workplace were not considered in evaluating the plaintiff's inhalation exposure. Instead the plaintiff's expert relied on air monitoring data taken from a laboratory worker working inside a laboratory with unknown ventilation rates. Therefore, the average benzene concentration estimated by Dr. Nicas is not a reliable estimate of Mr. Brown's exposure while using Shell's Reformate.

Dermal Dose

For the dermal dose Dr. Nicas utilized a dermal flux model. This model calculated the amount of benzene absorbed based upon a flux value (the amount of material that absorbs through the skin per the amount of surface area exposed) and the duration of exposure.

Even if dermal flux exposure estimation models had been validated, Dr. Nicas's extrapolation of a flux value from pure benzene to predict a flux value for reformate containing various hydrocarbon chemicals including benzene has not been determined or validated, has no known error rate and is therefore unreliable. This approach does not address the differences in exposures based on personal factors (individual differences) nor does it address factors associated with the exposure environment (environmental factors such as temperature, airflow across the skin surface, etc.). Most significantly, his equation does not reflect the differences in flux based on the solvent (product) vehicle (formulation) or combination of other chemicals in the mixture.

Dr. Nicas did not consider the evaporation of benzene from reformate over time and assumes a constant concentration of benzene in reformate. However, he assumed that there was an airborne exposure to the benzene evaporating from reformate during this activity. Therefore, the estimated absorbed dose that Dr. Nicas converted to an airborne equivalent 8-hour TWA concentration and then added to his inhalation concentration estimate was not a reliable estimate of Mr. Brown's dermal or total benzene exposure. Finally, there is no standard or accepted method utilized by OSHA, NIOSH or the ACGIH for adding dermal dose to the measured airborne concentration for comparison with occupational health standards and guidelines.

Another task described by the plaintiff was the cleaning up of oil spills. Dr. Nicas attempted to quantify Mr. Brown's short-term airborne exposure to benzene during oil spill cleanups. He stated that Mr. Brown cleaned up oil spills and "platform carryovers" both as a laborer/maintenance man and as a lease operator. According to Dr. Nicas's report, spills could involve anywhere from a fraction of a barrel to several barrels of oil. However, this statement is not supported by the deposition testimony of Mr. Brown. Dr. Nicas cited several Shell documents that presented the benzene content in crude oils from various locations. The benzene content ranged from 0.058% to 0.569%.

To determine the airborne concentration of benzene, Dr. Nicas selected values between the high and low points of the range of values for the amount of oil spilled and concentration of benzene in the crude oil and suggested that a 50-gallon oil spill would cover a surface area of

approximately 32 feet by 32 feet. He then assumed that 1% of the benzene in the crude oil would have evaporated rapidly in an air zone bounded by the surface area of the oil spill up to an elevation of five feet above the oil spill, essentially evaporating 1% of the benzene into a box the size of 32' x 32' x 5'. Based on this information, Dr. Nicas judged that during some spills Mr. Brown was exposed to benzene vapor concentrations exceeding 5 parts per million (ppm) over a 15-minute period of time. In this calculation the benzene in air concentration was 10.8 ppm benzene. He also stated that dilution air along with the removal of the oil would reduce this concentration to below 5 ppm as cleanup continued.

This calculation is flawed for several reasons. First of all, Dr. Nicas did not know the evaporation rate of benzene from crude oil. He provided no basis for the selected a value of 1% of the benzene in the oil being evaporated in an undesignated short time period. Secondly, he used a closed box model to represent the air space that Mr. Brown would have been exposed to during an oil spill cleanup. This closed box model did not consider the air flow on platforms out over open water and is not representative of the air space or environment that would have been around Mr. Brown during oil spill cleanups.[22] Therefore, Dr. Nicas's estimation of the short-term exposure concentration of benzene that Mr. Brown was exposed to during oil spill cleanups is neither relevant nor reliable.

However, if one were to take Dr. Nicas's approach of a box model and add ventilation (air flow) representative of the air speeds found in the area of South Pass [21], and assume the benzene evaporated at a rate of 4,996 mg/min (1% of benzene mass per minute from Dr. Nicas's report) the resulting air concentration would not exceed 0.3 ppm benzene in air and this level would decrease rapidly over time due to the removal of the spilled oil (see Attachment IV). The maximum concentration of 0.3 ppm would not have exceeded the consensus and regulatory standards of the time period during which Mr. Brown worked for Shell or current regulatory and consensus standards for benzene (see Attachment V).

Plaintiff's Expert Melvyn Kopstein's Report

Upon initial review of Dr. Melvyn Kopstein's report, it was evident that he cited documents and corresponding industrial hygiene data that had no relevance to Mr. Brown's work tasks or exposures. For example, Dr. Kopstein stated in his report that he relied on "two studies published in the peer-reviewed literature that present published benzene air monitoring data that are well in excess of threshold limit values (TLVs) for benzene at all times that Mr. Brown worked for Shell Oil and Shell Offshore." The Williams, et al (2005) paper pertained to benzene exposures associated with tasks performed on Marine Vessels. Dr. Kopstein stated that this publication indicated short-term exposures were well in excess of 50 ppm for tasks associated with petrochemicals (e.g. gasoline). This task involved checking gasoline

[22] National Data Buoy Center, http://www.ndbc.noaa.gov/station_page.php?station=burl1

tank levels on Swedish tankers with benzene content of 4% to 5 %. None of the tasks in the cited paper had any relationship to Mr. Brown's work tasks.

The other study cited by the plaintiff's expert was written by Caldwell et al. (2000), which is a compilation and analysis of the literature involving hydrocarbon solvent exposure data spanning over four decades. The data cited in this report is representative of personal air monitoring conducted on rubber spreading, gravure press operation, ink mixing, tanning, solvent cleaning, silk screening, adhesive application, fiberglass molding, stain removal, paint mixing, rubber mixing, etc. These processes, were not representative of Mr. Brown's job tasks while employed by Shell Oil or Shell Offshore as described in Dr. Nicas's report. Dr. Kopstein stated the 719 benzene samples taken had an average of 13.75 parts per million (ppm). However, this was not an accurate statement. The average of all these non-representative data points was actually 2.6 ppm which was representative of a great variety of solvents, with varying benzene content, and in varying workplace environments.

Dr. Kopstein stated he intended to employ the same methodology "as appropriate" that Shell used in their retrospective benzene exposure study at two refineries in 1984. Specifically, he will use odor as a means to quantify a range of exposure levels to an airborne petrochemical contaminant. He cited Ruth (1986) in stating "Odor thresholds are used routinely as a tool in recognizing and responding to potential hazards." Recognition of an odor is vastly dissimilar from quantifying a vapor concentration. In this same article Ruth stated in the opening sentence of the paper, "the sense of smell cannot be relied upon to evaluate the hazards of chemicals used in the workplace." There are no statistically valid methods for quantifying benzene exposure by odor determination. Odor detection is neither a standard nor accepted industrial hygiene practice for benzene exposure assessment.

Dr. Kopstein's intended use of odor as a means of evaluating benzene concentrations is neither relevant nor reliable. The use of odors as a means of quantifying ambient benzene concentrations is not relied upon as a means of evaluating occupational exposures. It is an accepted tenet of exposure assessment methodology that qualitative perceptions are of limited value and are far less accurate than quantitative data. According to Amoore and Hautala (1983), the nose is "...at best only semi quantitative, and it required calibration to determine its sensitivity..." The reason for this is that olfactory thresholds are extremely variable among subjects (Stevens, et al. 1988). Precise threshold values do not exist and an odor panelist's ability to detect an odor stimulus varies as a result of random variation in factors including alertness, attention, fatigue, events at the molecular level, and health status (ASTM 2004).

Conclusions

Based on the documents and literature I have reviewed I express the following opinions to a reasonable degree of scientific certainty. It is clear that neither Dr. Nicas nor Dr. Kopstein followed appropriate exposure methodologies. Their failure to adhere to these methodologies and their use of inappropriate data renders their opinions regarding Mr. Brown's alleged benzene exposure neither relevant nor reliable. Specific opinions regarding Drs. Nicas and Kopstein's report are as follows:

Dr. Nicas

- The industrial hygiene data used by Dr. Nicas to estimate Mr. Brown's airborne exposure to benzene from the Paraffin Cutting operation is not relevant to Mr. Brown's alleged exposure to benzene from the reformate. Therefore, his estimate of Mr. Brown's inhalation exposure to benzene is neither relevant nor reliable.
- Dr. Nicas's methodology for determining dermal dose has not been scientifically validated, is not reliable, nor is it a standard and acceptable industrial hygiene practice for quantifying dermal dose. The dermal routes of exposure have already been accounted for in the OSHA regulations and other standard setting agencies during the development of the standards. OSHA, ACGIH, and NIOSH neither require nor recommend quantifying dermal exposures and there is no means of comparing dermal exposure to occupational health standards or guidelines.
- Dr. Nicas's methodology for estimating Mr. Brown's short-term airborne exposure concentration to benzene from oil spill cleanup operations is not representative of Mr. Brown's exposure. His closed box model did not account for the substantial vapor dilution as the result of Mr. Brown's open air work environment. Futhermore, he provided no basis for his assumption as to the benzene evaporation rate and therefore was immediately available for inhalation. Both the lack of ventilation and the immediate evaporation of benzene assumption presented by Dr. Nicas render his opinion to be scientifically inaccurate.

Dr. Kopstein

- The references cited by Dr. Kopstein have no bearing on Mr. Brown's work tasks and therefore the cited data would not be representative of Mr. Brown alleged benzene exposure. Therefore, his estimate of Mr. Brown's inhalation exposure to benzene is neither relevant nor reliable.
- The reliance on an odor threshold as a means of quantifying ambient concentrations is not an accepted industrial hygiene practice or an appropriate means to assess exposures. There is significant inter- and intra- variability in an individual's ability

to detect odors. Odor thresholds that are available vary widely and, as such cannot be used to predict air concentration with any degree of scientific certainty. Therefore, Dr. Kopstein's reliance on odors cannot be considered relevant or reliable in assessing Mr. Brown's exposures.

My opinions are based on my more than 32 years of experience as an industrial hygienist and safety professional. My experience has included health hazard evaluations and audits of multiple operations within facilities similar to and the same as those workplaces experienced by Mr. Brown. My experience has also included the development of exposure assessment strategies, and training of employees who worked in numerous industrial operations. I also base my opinion upon portions of the scientific literature focused on occupational health hazard assessment.

To date, the following materials have been reviewed and/or relied on specifically for this case.

1. Plaintiff's Initial Disclosure
2. Plaintiff's Supplemental Initial Disclosure
3. Plaintiff's First Amended Complaint for Damages
4. Plaintiff's Employment Records
5. Plaintiff's Claim for Compensation
6. Report of Melvyn Kopstein, Ph.D., w/ CV, Testimony List and Publications
7. Report of Mark Nicas, 5 Jan 2009 w/ CV & References
8. Report of Peter F. Infante, L.L.C. w/CV
9. Report of Shelia L. Butler, MD, MPH, 5 January 2009
10. Report of Robert Harrison, 31 December 2008
11. Ignacio, J.S. and Bullock, W.H. A Strategy for Assessing and Managing Occupational Exposures, 3rd Ed. American Industrial Hygiene Association, Fairfax, VA 2006.
12. DiNardi, SR. The Occupational Environment – Its Evaluation and Control. AIHA Press, Fairfax, VA 1997.
13. Esmen N.A. "Retrospective Industrial Hygiene Surveys" Am. Ind. Hyg. Assoc. J. 40 (1979): 58-65.
14. Checkaway et al., Industrial Hygiene Involvement in Occupational Epidemiology, Am. Ind. Hyg. Assoc. J. 48 (1987) 515-523.

15. Mona Baumgarten, J. Siemiatycki, G. Gibbs, Validity of Work Histories Obtained by Interview for Epidemiologic Purposes, Am. J. Epidem. 118 (4) 1983.

16. Denis Hemon, et al. Retrospective Evaluation of Occupational Exposures in Cancer Epidemiology: A European Concerted Action of Research, Appl. Occup. Environ. Hyg. 6 (6) 1991.

17. Nicas M, Plisko MJ, and Spencer JW. "Estimating Benzene Exposure at a Solvent Parts Washer." Journal of Occupational and Environmental Health 3(2006): 284-291.

18. Spencer, John W. and Plisko, Marc J. 'A Comparison Study Using a Mathematical Model and Actual Exposure Monitoring for Estimating Solvent Exposures During the Disassembly of Metal Parts." *Journal of Occupational and Environmental Hygiene*, **4** (2007): 253 – 259.

19. Plisko M and Spencer JW. "Evaluation of a mathematical model for estimating solvent exposures in the workplace." JCHAS (2008):

20. Fiserova-Bergerova V. "Letter to the Editor: RE: Response to Bunge's Letter to the Editor." American Journal of Industrial Medicine 34 (1998): 91.

21. Jakasa I and Kezic S. "Evaluation of in-vivo animal and in-vitro models for prediction of dermal absorption in man." Human & Experimental Toxicology 27 (2008): 281-288.

22. NIOSH Manual of Analytic Methods is available at http://www.cdc.gov/niosh/nmam/ and includes validated sampling and analytical methods. OSHA validated sampling and analytical methods are available at http://www.osha.gov/dts/sltc/methods/index.html. Information regarding limit of detection, range, and precision; i.e. sampling and analytical error is provided for validated NIOSH and OSHA methods.

23. Blank, I.H., and D. J. McAuliffe. "Penetration of Benzene through Human Skin." J. *Invest. Dermatol,* **85** (1985): 522-526.

24. Hanke, J., T. Dutkiewicz, and J. Piotrowski. 1961. "The Absorption of Benzene through the Skin in Man." *Med. Pracy,* **12** (1961): 413-426. (OSHA translation and reprint with permission in International Journal of Occupational and Environmental Health, 6 (2000): 104-111.

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26. OSHA. "Dermal Dosimetry" http://www.osha.gov/SLTC/dermalexposure/dosimetry.html

27. Adami, et al. "Penetration of benzene, toluene and xylenes contained in gasolines through human abdominal skin in vitro." Toxicology in Vitro 20-8 (2006): 1321-1230.

28. Franz, TJ. Chapter 5 "Percutaneous Absorption of Benzene." In Advances in Modern Environmental Toxicology. Volume VI – Applied Toxicology of Petroleum Hydrocarbons. Editors: MacFarland, Holdsworth, MacGregor, Call, and Lane. Princeton Scientific Publications, Inc. 1984: 61-70.

29. Riviere, JE and Brooks, JD. "Prediction of dermal absorption from complex chemical mixtures: incorporation of vehicle effects and interactions into a QSPR framework." SAR and QSAR in *Environmental Research,* **18** (2007):1, 31 — 44.

30. Fiserova-Bergerova V. "Relevance of occupational skin exposure." Annals of Occupational Hygiene 37 (1993): 673-685. p. 677

31. OSHA Preamble to the Benzene Standard. Federal Register 52(176): September 11, 1987; pp. 34487-34505.

32. Boman, A. and Maibach, H.I. "Influence of Evaporation and Solvent Mixtures in the Absorption of Toluene and n-butanol in Human Skin in vitro." *Annals of Occupational Hygiene,* **44** (2000): 125-135.

33. "Odor Thresholds for Chemicals with Established Occupational Health Standards," American Industrial Hygiene Association, Fairfax, VA, 1989.

34. A Strategy for Occupational Exposure Assessments. Edited by Neil C. Hawkins, Samuel K. Norwood, James C. Rock, AIHA, Fairfax, VA, Third Printing, 1995.

35. *A Toolbox of Mathematical Models for Occupational Exposure Assessment*, Professional Development Course 401, American Industrial Hygiene Conference and Exposition, Atlanta, GA, May 1998.

36. ACGIH TLV Committee. "Benzene." Documentation of the TLVs and BEIs. ACGIH Press, Akron, Ohio (2001) pp Benzene BEI -1 to 14.

37. AIHA Exposure Assessment Strategies Committee Modeling Subcommittee. Mathematical Models for Estimating Occupational Exposure to Chemicals. Charles Keil, Editor. AIHA Press, 2000. pp. 65-75.

38. American Conference of Governmental Industrial Hygienists (ACGIH), Threshold Limit Values, 1946 to present.

39. Plog, Barbara, A., Fundamentals of Industrial Hygiene, Third Edition, National Safety Council, Chicago, IL, 1988.

40. National Data Buoy Center, http://www.ndbc.noaa.gov/station_page.php?station=burl1

41. U.S. Department of the Interior, Minerals Management Service. Investigation of Shell Pipe Line Corporation Pipeline Leak South Pass Block 65, December 30. 1986, page 16, Attachment 1.
42. Depositions of Ben N. Brown, taken 7, 19 & 20 January 2009 and 11 & 12 February 2009
43. Shell Industrial Hygiene Monitoring Data, bates numbers SHELL BBROWN 00091-00142, 00144-00259
44. Shell E & P Manuals No. 1-3
45. Material Safety Data Sheets
46. Shell Offshore Inc.'s Procedure for Clearing Plugged or Partially Plugged Lines
47. 759 Crude, Condensate and Natural Gasoline Assays Supplied by Mfgr. – Plans and Analysis, bates numbers SHELL BBROWN 002120-002137
48. Benzene Contents of Crude Oils Transported in SPLC Pipeline Systems, bates numbers SHELL BBROWN 005711-005716.

My summary report is based on the information available to me at this time. Upon receipt of additional information, I reserve the right to determine the impact, if any, of the new information on my opinions and conclusions, and to revise my opinions and conclusions as necessary.

Sincerely,

John W. Spencer, CIH, CSP
President

JWS/ddj

Attachment I: Curriculum vitae of John W. Spencer, CIH, CSP
Attachment II: John Spencer Four-Year History of Testimony
Attachment III: Table 1: Benzene Dermal Flux Data for Various Liquid Mixtures Containing Variable Benzene Levels
Attachment IV: Oil Spill Calculations Using Dr. Nicas's Box Model
Attachment V: Historical Occupational Exposure Limits for Benzene

ATTACHMENT I

Curriculum vitae
John W. Spencer, CIH, CSP

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CURRICULUM VITAE

JOHN W. SPENCER, CIH, CSP

Date of Birth: 12 February 1954
Citizenship: USA

Education:

1980-1981	National Institute for Occupational Safety and Health and OSHA Training Institutes – Special Programs
1973-1976	B.S. Biological Sciences University of Maryland College Park, Maryland
1972-1973	St. Mary's College St. Mary's City, Maryland

Professional Experience:

1993 - Present	President Environmental Profiles, Inc. Baltimore, Maryland
June 1990 - 1993	Vice President and Director of Environmental Sciences National Medical Advisory Service Bethesda, Maryland
1988-1990	Principal Daft-McCune-Walker, Inc. Towson, Maryland President DMW Environmental Services, Inc. a subsidiary of Daft-McCune-Walker
1987-1988	Corporate Industrial Hygienist and Environmental Coordinator United States Fidelity and Guarantee Company Baltimore, Maryland
1982-1987	Director of Industrial Hygiene and Occupational Health Programs United States Coast Guard, 5th District Portsmouth, Virginia

Professional Experience (cont.):

1980-1982	Team Leader/Industrial Hygienist National Institute for Occupational Safety and Health National Occupational Hazard Survey Cincinnati, Ohio
1977-1980	Industrial Hygienist Equitable Environmental Health Rockville, Maryland

Certifications and Registrations:

1987	American Board of Industrial Hygiene Certified Industrial Hygienist
1991	Board of Certified Safety Professionals Certified Safety Professional
2003	Certified Indoor Air Quality Consultant

Professional Societies:

	American Indoor Air Quality Council
	American Industrial Hygiene Association
	American Board of Industrial Hygiene
	American Conference of Governmental Industrial Hygienists
	Board of Certified Safety Professionals
	American Association for the Advancement of Science
	Society for Chemical Hazard Communication
1999	Member, American Society of Safety Engineers
1998	Member, American Association for the Advancement of Science
1996	Member, New York Academy of Sciences
1993-94	Member, Maryland Industrial Hygiene Council
1992-93	President, American Industrial Hygiene Association, Chesapeake Section
1992	President-Elect, American Industrial Hygiene Association, Chesapeake Section

Committees:

American Industrial Hygiene Association:
Product Health and Safety Committee (1991-1995)
- MSDS and Labeling and other Warning Issues
Emergency Response Planning Committee (1991-1999)

Awards:

1987	USF&G Company Excellence Through Service Award
1976	National Institutes of Health Outstanding Achievement Award

Selected Project Management Experience:

2001	Director of health, safety, and environmental management for a ship recycling firm. Managed the proper removal of asbestos, PCB, mercury, lead, petroleum products, and other regulated substances.
1997	Planned and conducted facility audits for health and safety regulatory requirements and Voluntary Protection Programs elements. Completed eleven (11) facilities in a three-week period using in-house developed software auditing and tracking tools.
1994-1996	Developed and implemented exposure assessment strategies of film processing operations. The operations included mass color film processing, and color film processing during the operation of a minilab. Investigations have also included the review of potential chemical exposures resulting from the use of X-ray development equipment in private doctors' offices and hospital environments.
1994	Conducted oversight of the environmental clean up of a U.S. naval aircraft carrier during a shipbreaking process. Evaluated for contaminated waters, painted surfaces, PCB, and asbestos containing materials. Insured the proper removal and disposal of all waste materials.
	Developed product warning labels and material safety data sheets for industrial and consumer products.
	Managed the final clearance of asbestos from approximately 25 occupied apartment buildings. Oversaw clean-up strategy, including air monitoring of work and adjacent spaces.

Selected Project Management Experience (cont.):

1994	Have conducted numerous indoor air quality investigations of commercial office space, clinical laboratories, and on University campuses. Assessments included review of the heating ventilating and air condition system, management programs to respond to IAQ complaints and real time monitoring for chemical, physical, and biological agents.
1994	Conducted audits of health, safety, environmental and management programs of multiple chemical processing facilities.
1991, 1992, 1993	Designed and implemented several comprehensive product risk analysis evaluations for product manufacturers. Analysis included hazard identification, toxicological assessments, industrial hygiene exposure assessment, and risk characterization. Recommendations to control or eliminate potential user exposures were provided.
1991, 1992, 1993	Supplemental information for product warnings by the MSDS, labels, and technical information bulletins was also included.
1990, 1991, 1993	Provided expert opinion on sufficiency of labels and warnings for chlorinated solvents, isocyanate, and benzene containing products.
1989	Evaluated a 450-acre manufacturing facility with nearly 3 million square feet of manufacturing and warehouse space for hazardous substances which may have represented liability to the potential purchaser under CERCLA. Reported directly to the Rouse Company in Columbia, Maryland as their environmental advisor for the approximate $43 million property transfer.
1988-1990	Have conducted numerous exposure assessments to evaluate actual personal exposure levels that resulted from various workplace tasks and environments. Benzene, asbestos, formaldehyde, chlorinated solvents, and automobile by-products of combustion were evaluated via real-time assessments to assess actual personal exposures.
1988-1989	Developed a groundwater monitoring and protection program for a new golf course facility. Determined environmental base line parameters to be applied to subsequent future groundwater sampling. Assessed pesticide environmental fate mechanisms and degradates resultant from turf management practices.

Selected Project Management Experience (cont.):

1988-1989	Evaluated hazardous material haulers exposure to cargo during pick-up, transit, and off-loading. Established recommendations for personal protective equipment and work practices to reduce and eliminate significant exposures to cargo. Chemicals evaluated included the isocyanates, MDI and TDI and methylene chloride.
1986	Conducted a detailed health hazard evaluation of an EPA Superfund (CERCLA) site in New Jersey. Monitored hazardous waste site workers' exposure to a multitude of chemical contaminants.
1985-1987	Development and implementation of Occupational Medical Monitoring, Hearing Conservation, Lead, Asbestos and Hazard Communication programs for approximately 4,000 military and civilian personnel involved in manufacturing, office and residential environments. Measured exposures to benzene, aliphatic hydrocarbons, and other chemical and physical agents in industrial and shipboard environments.
1985	Conducted Asbestos and Lead Training Programs for shipyard workers involved in abatement procedures. Instructed workers in the areas of potential health hazards, health and safety measures and methods for reducing their exposure. Prepared labels for in-house product use.
1980-1982	Led a team of seven industrial hygienists in the NIOSH National Occupational Hazard Survey. My team visited approximately 1,500 facilities across the United States. We reviewed management practices related to employee safety and health, conducted wall-to-wall audits of the facility, reviewed product labels and MSDS, inventoried products and their constituents from readily available information and developed a product database.
1979	Conducted a wall-to-wall survey of a pharmaceutical facility evaluating worker exposures and recommended methods for regulatory compliance.

Professional Development Courses:

Risk Assessment Symposium, AIHA 6-7 November 2008, Tampa, FL

Introduction to Monte Carlo Uncertainty Analysis, PDC 8, 26 September 1999, PCIH '99

Risk Assessment, PDC 6, 26 September 1999, PCIH '99

Mathematical Models for Occupational Exposure Assessment, PDC 402, 6 June 1999, AIHCE

Professional Development Courses (cont.):

International Hazard Communication, AIHA/SCHC (12 hrs)

Environmental Toxicology, Hood College (24 hrs)

Man-Made Mineral Fibers: Status of Health Risk Assessment, Johns Hopkins University (12.5 hrs)

Health Hazard Recognition & Evaluation, OSHA Institute (80 hrs)

Health Hazard Recognition & Evaluation, NIOSH Training Institute (80 hrs)

Chemical Process Industries, University of Cincinnati (40 hrs)

Industrial Ventilation Conference, North Carolina State University (40 hrs)

Mechanisms of Toxicology, Johns Hopkins University (25 hrs)

Asbestos Symposium, Johns Hopkins University (8 hrs)

Loss Control Management, U. S. Coast Guard (40 hrs)

Pulmonary Medicine Topics, U.S. Navy Conference (8 hrs)

Navy Occupational & Environmental Health Workshop, U.S. Navy Conference (40 hrs)

Comprehensive Review of Industrial Hygiene, University of Utah (40 hrs)

Air Surveillance for Hazardous Materials, U.S. EPA (40 hrs)

Appropriate IH Data Collection for Future Occupational Epidemiology Studies (4 hrs)

Certified Indoor Air Quality Consultant Study/Review Course (20 hrs)

Selected Speaking Engagements:

2007 "A Validation Study of a Mathematical Model for Estimating Solvent Exposures in the Workplace." American Industrial Hygiene Conference and Exposition, June 2007.

"The Implications of Input Variables Selection When Modeling Occupational Exposures." American Industrial Hygiene Conference and Exposition, June 2007.

2003 "Estimating Past Exposures- The Scientific Basis for Reconstructing Asbestos Dose for Groups and Individuals." American Industrial Hygiene Conference, May 2003

Selected Speaking Engagements (cont.):

2002	"Where do we start? The proper response to an indoor air quality complaint. Investigation and testing techniques; determining causes; remediation," 18th Annual Maryland Workers' Compensation Educational Association Inc. Conference, 24 September 2002.
2001	"Generating Exposure Data on Historical Activities or Products", American Industrial Hygiene Conference, 4 June 2001.
	"Evaluation of Chemical Exposures in Mammography X-Ray Development," American Industrial Hygiene Conference, 4 June 2001.
	"Comparison of Direct and Indirect Sample Preparation Methods for Asbestos Analysis", American Industrial Hygiene Conference, 6 June 2001.
1999	"The Actual Contribution of Airborne Asbestos Fibers to the Work Environment From Asbestos Gaskets", American Industrial Hygiene Conference and Exposition, 7 June 1999.
1998	Federal Safety and Health Council of Central Maryland Health & Safety Programs: Auditing, Self-Assessments and Issues Tracking
1995	"Environmental Health & Safety Auditing — Performance Measures," Program Chairperson, Johns Hopkins University, Baltimore, Maryland, October 1995
	"Health & Safety Audits Course", Program Chairperson, Government Institute, Orlando, Florida, February 1995
	"Issues Critical to Growth", Maryland Chamber of Commerce, Baltimore Leadership Training, Baltimore, MD, 15 May 1995
1994	"Health and Safety Compliance Auditing Course", 3 days UNOCAL Corporation, Los Angeles, CA, August & September, 1994
	"Indoor Air Quality; Putting the Issues into Perspective", American Industrial Hygiene Association, Chesapeake Section, Professional Development Conference. U.S. Naval Academy, Annapolis, MD, October 1994
1994	"Computer Applications for Managing Health, Safety and Environmental Programs" Safety Council of Maryland, June 1994
	"Emergency Response Planning" Round table American Industrial Hygiene Conference, May 1994.

Selected Speaking Engagements (cont.):

1994	The OSHA Update Conference, Government Institutes, Inc., Washington, DC, 29-30 October 1992 — Health & Safety Audits
1992	The Environmental Management Development Summer Institute, Government Institutes, Washington, DC, 12 June 1992 — Hazard Communication Requirements — Preparing for Inspections and Working with the Regulators
	Chairperson for "Product Risk Assessment" Roundtable, AIHA National Meeting
	Program Chairperson for "Health and Safety Auditing," Government Institute Programs
1989	Maryland Institute for Continuing Professional Education of Lawyers Advanced Real Estate Institute Environmental Issues in Land Development
1988	DMW/Cook, Howard, Downes and Tracy; Land Use Seminar Property Investigations for Hazardous Substances for Real Estate Transactions
1987	USF&G Loss Control Seminar Environmental Hazard Assessment
1986	U.S. Coast Guard Marine Safety Training School Environmental and Occupational Hazard Assessment

Professional Conference Poster Presentations:

1. Plisko, M.J. and Spencer, J.W. 1999. *Measurement for Continuous Improvement of Health, Safety, and Environmental Programs.* American Industrial Hygiene Conference and Exposition, Toronto, Canada. June.
2. Spencer, J.W. 2000. *An Example of a Quantitative/Environmental Exposure Database-An Information Resource.* American Industrial Hygiene Conference and Exposition, Orlando, Florida. May.
3. Burrelli, L., Nealley, M., Plisko, M., Spencer, J. 2004. *Exposure Assessment: An Evaluation of Benzene from the Application and Use of Spiked Penetrating Solvents.* American Industrial Hygiene Conference and Exposition, Atlanta, Georgia. May.
4. Plisko, M. and Spencer, J. 2004. *Using a Physical-Chemical Mathematical Exposure Model for estimating Occupational Exposure.* American Industrial Hygiene Conference and Exposition, Atlanta, Georgia. May.

Professional Publications:

1. Torrence, P.R., and Spencer, J.W. 1978. "5- 0- Alkylated Derivatives of 5-Hydrox-2[1]-deoxyuridine as Potential Antiviral Agents." *Journal of Medicinal Chemistry.* 21:228.
2. Gots, R.E., Gots, B.A., and Spencer, J. 1992. "Proving Causes of Illness in Environmental Toxicology: 'Sick Buildings' as an Example." *Fresenius Envir Bull.* 1:135.
3. Spencer, J.W. 1992. *Health and Safety Audits.* Government Institutes, Inc.
4. Rose, V.E. and Spencer, J.W. 1995. *Hazard Communication: An AIHA Protocol Guide.* AIHA Publication.
5. Spencer, J.W., Plisko, M., Balzer, R. 1999. "Asbestos Fiber Release from the Brake Pads of Overhead Industrial Cranes" *Occupational & Environmental Hygiene.* 14:397-402.
6. Nicas, M., Plisko, M.J., Spencer, J.W. 2006. "Estimating Benzene Exposure at a Solvent Parts Washer." *Journal of Occupational and Environmental Hygiene.* 3:284-291.
7. Spencer, J.W. and Plisko, M.J. 2007. "A Comparison Study Using a Mathematical Model and Actual Exposure Monitoring for Estimating Solvent Exposures During the Disassembly of Metal Parts." *Journal of Occupational and Environmental Hygiene.* 4:253-259.
8. Boelter, F.W., Spencer, J.W., Simmons, C.E. 2007. "Heavy Equipment Maintenance Exposure Assessment: Using a Time-Activity Model to Estimate Surrogate Values for Replacement of Missing Data." *Journal of Occupational and Environmental Hygiene.* 4:525-537.
9. Plisko, M.J. and Spencer, J.W. 2008. "Evaluation of a Mathematical Model for Estimating Solvent Exposure in the Workplace." *Journal of Chemical Health and Safety.* (15) 3:14-21.

ATTACHMENT II

John Spencer Four-Year History of Testimony

John W. Spencer

Case Style	Court	Cause Number	Deposition
Marian Smith et al. vs. Able Supply Company, et al.	District Court, 131st Judicial Court, Bexar County, Texas	Cause No. 2001-CI-08509	✔
Jo Ann Cave vs. Exxon Mobil Corporation et al.	In the Circuit Court for Marshall County West Virginia	Civil Action No. 01-C-19M	✔
Walter T. Graves, Jr. vs. Riverwood International Corp. et al.	4th Judicial District Court for the Parish of Quachita County, Louisiana	Docket No. 00-1748	✔
Mathias, Diane vs. AC&S, Inc., et al.	In the County Court at Law No. 3, El Paso County, Texas	Cause No. 2000-4218	✔
Paul Verret and Judith Verret vs. American Biltrate, et al.	In the District Court of Tarrant County, Texas, 17th Judicial Court	Cause No. 17-200000-03	✔
Conrad, Merele vs. Ashland	State of New York Supreme Court, County of Erie	Index No. I2000/5809	
Robinson, Larry vs. NVF Yorklyn	Superior Court of Deleware, New Castle County	02C-04-232	✔
Douglas M. Spann and Theresa Spann vs. Airco, Inc, et al	District Court for the Southern District of Mississippi, Jackson Division	Civil Action No. 3:02CV1645WS	✔
James Boren and Ginger Boren v. The Dow Chemical Company, et al.	District Court of Brazoria County, Texas, 239th Judicial District	17958-JG01	✔
Daniel T. Minnehan, et al., vs. Radiator Specialty Co., et al.	District Court of Brazoria County, Texas, 239th Judicial District	21916*JG02	✔
Donald H. Reynolds and Nancy A. Reynolds vs. Amchem Products, Inc.	State of New York, Supreme Court: County of Niagra	Index No. 117820	
Zebulon Little vs. Garlock	Circuit Court of Newport News	At Law No. 37073V-04	✔
Milton Watts, et al. vs. Radiator Specialy Company, et al.	Circuit Court of Smith County, Mississippi	Civil Action No. 2002-364	
Michael A. LeBron and Pamela LeBron, his wife vs. Shell Oil Company, et al	Circuit Court of Cook County, Illinois County Department – Law Division	Case No. OO L 10021	✔

John W. Spencer

Case Style	Court	Cause Number	Deposition
Daniel Johnson vs. Caterpillar	Superior Court of the State of California, County of San Francisco - Court of Unlimited Jurisdiction	Case No. 432923	✔
George Adams, et al vs. Honeywell International, Inc., et al	U.S. District Court for the Western District of Arkansas - Texarkana Division	No. 02-4076; CIV-2000-31; CIV-2000-32;	
Raman Kalyanaraman and Meena Kalyanaraman, his wife, vs. Bayer Corporation and James Taylor, individually	Circuit Court of Marshall County, West Virginia	Civil Action No. 98-C-210M	
Gary Snyder, et al. v. ACandS, Inc., et al.	Circuit Court for Baltimore City	Case No. 24X01001969	✔
Thomas D. Bruner, et al. v. American Asbestos Co., et al.	Superior Court of the State of California, County of San Francisco - Court of Unlimited Jurisdiction	Case No. 432439	✔
James Urbach and Josephine Urbach v. The Flintkote Company, et al.	Court of Common Pleas, Philadelphia County, Pennsylvania, Civil action-law	Civil Action No. 002638	
Daniel C. Johnson and Vaneisa L. Johnson v. American Asbestos, et al.	Superior Court of the State of California, County of San Francisco - Court of Unlimited Jurisdiction	Case No. 432923	
Lee Dell Craft, Sr., et al. v. Intracoastal Tubular Services, Inc., et al.	Civil District Court, Parish of Orleans, State of Louisiana	No. 97-06178	✔
Donald Yates, et al. v. A.W. Chesterton, et al.	Little River County, Arkansas	No. CIV 2000-203-3	✔
Denizilye M. Douglas, as Personal Respresentative of the Estate of Earl E Douglas Deseased vs. Ashland, Inc.,	Greenup Circuit Court Civil Division	Case No. 01-CI-00392	✔
Paul S. Rose , administrator of the Estate of Deborah K. Rose vs. AEP Generating Company	Circuit Court of Kanawha County, West Verginia	Civil Action No.03-C-9600	✔

John W. Spencer

Case Style	Court	Cause Number	Deposition
Deborah Rosen, Individually and as Personal Respresentative of the Estate of Sherwin Rosen vs. Asbestos Corporation Limited, et al.	Superior Court Of California, County Of Alameda	No. 2002 049017	✔
Edith Naomi Ladner, on Behalf of Haley Brianna Ladner, Deceased vs. E.I. Dupont de Nemours Corp, et al. and Glen Ray Strong and Connie Ann Strong vs. E.I. Dupont de Nemours Corp, et al.	Circuit Court of Jones County, Mississippi, Second Judicial District, City of Laurel	No. 2005-59-CV3 and No. 2005-57-CV3	✔
Gary Massey, Plaintiff vs. Calvin F. David, Defendant	Circuit Court of The Eighth Judicial Circuit, in and for Alachua	Case No. 98-2434 CA Division J	
Leonard Ryan, Individually and as Plaintiff ad litem for Nancy Ryan, deceased vs. BP Corporation North	In The Circuit Court For Jackson County, Missouri At Independence	Case No. CV 223271	✔
William Williford, et al vs. Aqua-Chem, Inc., et al.;	In The 11th Judicial District Court; Harris County, Texas	Case No. 2004-19266	✔
In Re: Asbestos Case of Hatch, James & Dodge and G. Patterson Keahey Howard Sortor and Nadine Sortor, Plaintiffs, v. Asbestos Defendants	At The Plaintiffs House at 14713 West Chubbuck Road, Chubbuck, Idaho	Case No. 040909899 Master Case No. 010900863	✔
In Re: Asbestos Personal Injury Litigation, David Blair Maynard and Linda Carol Maynard, his wife, Plaintiffs v. A W Chesterton Company, et al., Defendants	In The Circuit Court of Kanawha County West Virginia	Civil Action No. 9600, Civil Action No. 04-C-3392	✔
In Re: Asbestos Litigation, Grace E. Goodnite, Personal Representative of the Estate of Donald Goodnite	In the Ciruit Court of Kanawha County West Virginia	Civil Action No. 03-C9600; Civil	✔
James E. Morrison and Sandra A. Morrison vs. American Asbestos Company	Superior Court Of The State Of California In and For The County Of San	No. 432013	
Lucas E. Hicks, Jr. vs. Garlock, Inc. et al.	In The Circuit Court Of The City Of Newport News, Virginia	No. 38116P-03	✔

John W. Spencer

Case Style	Court	Cause Number	Deposition
Raymond N. Crockett, et ux, vs. Garlock Sealing Technologies, LLC, et al.	In The Circuit Court Of The City Of Newport News, Virginia	No. 38356P-03	✔
Debora Rosen et al., vs. The Regents of the University Of California et al.	Superior Court of the State of California in and for the County of Alameda	Case No. 2002-049017	✔
Anne Pretko, Individually and as Personal Representative Of the heirs and Estate of Edward J. Pretko, Deseased,	In The District Court 11th Judicial DistrictHarris County, Texas	Case No. 2004-11072	✔
Paul L. Palmer, Sr., Plaintiff vs. A.O. Smith Corporation, et al., Defendants	In The Circuit Court Third Judicial Circuit Madison County, Illinois	Case No. 04-L-167	✔
Pota Koutrobis, Individually and as Personal Representative of the Heirs and Estate of Christo	In The District Court Harris County, Texas 11th Judicial District	Case No.2004-11066	✔
Marian Horr, et al., Plaintiffs vs. Allied Packing, Inc. et al., Defendants	In The Superior Court Of The State of California In and For The County Of	Case No. RG03 104401	
Doris Sue Scott, Individually and as Representative of the Estate and as Wrongful Death Beneficiary of Archie	In The District Court Of Brazoria County, Texas 23rd Judicial District	Cause No. 23789*BH04	✔
Sandra Sue Fullen, et al., Plaintiff(s), v. Philips Electronics North America Corporation et al., Defendant(s)	In The Circuit Court Of marion County, West Virginia	Case No. 01-C-319	✔
John Ringstaff and Karen Ringstaff vs. Amoco Chemical Company, et al.	In The District Court Of Galveston County, Texas 56th Judicial District	Case No. 03CV-0551	✔
Xavier Loyola and Cordelia Loyola vs. Union Oil Co.of California, a Calif. Corp; Shell Chemical Co. a Del.Corp.;	Superior Court Of The State Of California For The County Of Los	Case No. BC 280498	✔
Samual Stacey v. Garlock, Inc. & Chesterton	In The Circuit Court of Richmond Virginia	Case No. LT 835	✔
Barbara Bercu vs. BICC Cables Corporation, et al.	In The Supreme Court Of The State Of New York All Counties Within New	Index No. 03-109091	✔
Ann Stubbs Individually and as Representative of the Estate of Ben L. Stubbs, Deceased and Herbert W.	In The District Court 128th Judicial District Orange County, Texas	Cause No. A-030272CC	✔
Asbestos Personal Injury Litigation May 2006 Trial Group	In The Circuit Court of Kanawha County West Virginia	Civil Action No. 03-C-9600	✔

John W. Spencer

Case Style	Court	Cause Number	Deposition
Ann P. Horkin, Individually and as Executrix of the Estate of Patrick C.Horkan Plaintiff v. Bondex International, Inc.	Commomwealth Of massachuetts Middlesex, SS Superior Court	Trial Court No: 04-3928	✔
Nancy Barry Ferrara Individually and as Personal Respresentative of the Heirs and Estate of Louis Anthony	In The District Court Of Harris County, Texas 11th Judicial District	Cause No. 2004-07963A	✔
Roger Redditt Plaintiff, v. American Optical Corporation, et al. Defendants	In The Circuit Court Of Warren County, Mississippi	Civil Action No. 04-0017 CI	✔
Edwin L. Higgings Plaintiff v. Copeland Corporation et al., Defendant	Superior Court Of The State of California For The County Of San	Case No.422161	✔
Glenn Keeran and Darleen Keeran vs. Ametek Inc., et al.	For The Superior Court of California In The County of Los Angeles	Case No. BC 347728	✔
David Angell vs. Brown & Root	In The District Court of Nueces County, Texas 148th Judicial District	Cause No. 00-05021-00-0-E	✔
Ronald Dutton Plaintiff v. Fisher Controls International, LLC et al.	Superior Court of California County of San Francisco	No. 420972	✔
Justin Detel Plaintiff v. BP Corporation North America Inc., et al., Defendants	In The 16th Judicial Circuit Court of Jackson County, Missouri	Case No. 04 CV 207637	✔
Raymond Jenkins, et al., Plaintiffs, v ACandS, Inc., et al., Defendants	In The Circuit Court For Baltimore City	Case No: 24x03001108	✔
Marian Gookstetter, Individually, as Wrongful Death Heir, and as Successor-in-Interest to Jay Gookstetter Plaintiff v.	Superior Court of California County of San Francisco	No. 402713	✔
Kenneth L.Anderson and Ruby J. Anderson, Husband and wife Plaintiff vs. Caterpillar, Inc.	In The Superior Court Of The State Of Washington In and For The County Of	No. 05-2-04551-5 SEA	
Vicki Tatera, et al., Plaintiff vs. Union Carbide Corp., et al., Defendants	In The Circuit Court of Milwaukee County State of Wisconsin	Case No. 04-CV-008167	✔
Najala Lindquist, As Executrix (appointment pending) Of The Estate Of George Lindquist and Individually As	In The Superior Court For The State Of Rhode Island County Of Providence	Case No. 06-2416	✔
Ronald Redman and Jeri Redman Plaintiffs, vs. A.W. Chesterton Company, et al. Defendants	Superior Court of The State of California in and For The County of San	Case No. 452158	✔

John W. Spencer

Case Style	Court	Cause Number	Deposition
as the Administrator of the Estate of and as the Wrongful Death Beneficiary of Walter J. Mielke, Deseased Plaintiff	In The United States District Court for the Southern District Of Iowa Central	Case No. 4:05-CV-88	✔
Representative Of The Heirs and Estate of Warren Cooper, vs. A.W. Chesterton, et al.,	In The District Court Of Harris County, Texas 11th Judicial District	Case No. 03-12225-B	✔
Myrl Lawrence, Plaintiff v. A.W. Chesterton Co., et al., Defendants	In The Circuit Court For Ashley County, Arkansas In And For The State Of	Case No. CIV 2000 73-2	✔
Edgel Orr, Plaintiff, v. A. W. Chesterton Co., et al., Defendants	In The Circuit Court For Ashley County, Arkansas In And For The State Of	Case No. CIV2002-99-3	✔
Kenneth F. Balthazar and Sandra L. Balthazar Plaintiffs, v. A.W. Chesterton Co. et al. Defendants	Commonwealth of Massachusetts	Civil Action No. 06-3620	✔
Donald Carroll, et al., Plaintiffs v. ACandS, Inc., et al., Defendants Case Affected: John J. Wehner	In The Circuit Court For Baltimore City	Meso Trial Group Consolidated No.	✔
Mildred Jones, Individually and as Personal Representative of the Heirs and Estate of Glenn Jones, Deseased, Vicki	In The District Court Harris County, Texas 11th Judicial District In The	Cause No. A171428	✔
Ljubinka Valesh and Joseph Valesh, Plaintiffs, vs. ANDEX Co. doing business as Anderson Pest Control;	In The Circuit Court of Cook County Department - Law Devision - State of	Case No. 04 L 4360	✔
Ronald S. Millender Jr., et al. v. American Insurance Company, et al.	Eighteenth Judicial District Court Parish of Iberville State of Louisiana	Case No. 63,286	✔
James Bruce and Natalie Bruce, Plaintiffs, vs. Allis-Chalmers Corporation et al., Defendants	In The Superior Court Of The State Of California In And For The County Of	Case No. 45727	✔
Joseph Boyd et ai., Plaintiffs vs. Lincoln Electric Company, et al., Defandants	In the Court Of Common Pleas of Cuyahoga County, Ohio	Case No. CV-04-545413	✔
Dennis Yankee and Sandra Yankee, husband and wife, Plaintiffs vs. ALCOA, Inc et al., Defendants	In The Superior Court Of The State Of Washington In and For The County Of	Case No. 06-2-29183-2	✔
Douglas and Helen West, Plaintiffs vs. Aqua-Chem, et al., Defendant	In The Superior Court Of The State Of California For The County Of San Francisco	No, SFSC 450293	✔

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Case Style	Court	Cause Number	Deposition
Steven Pelley, Plaintiff, vs. Afton Pumps, Inc. et al., Defendants	Superior Court Of The State Of California For The County Of Los Angeles	Case No. BC 358812	✔
Dorothy Ann Jackson, Personal Respresentative of the Estate of James E. Jackson, Dec'd. (D/OD 5/30/03) Plaintiff, v. A-C Product Liability, et al., Defendants	In The United States District Court For The Northern District Of Ohio Esatern Division	Case No. 1:99CV10802	✔
Charles Wilson and Laura Wilson, Plaintiffs, vs. Rycoline Products, Inc., et al., Defendant	In The United States District Court For The Eastern District Of Texas Marshall Division	Civil Action No. 2: 06-cv-286	✔
The Higbee Company v. Greater Lakeside Corporation	United States District Court For The Eastern District Of Louisiana	Cilvil Action No. 06-2848	✔
Jeannine Hamman, Plaintiff v. American Oil Company, Defendant	In The District Court Jefferson County, Texas 172ND Judicial District	Cause No. E-173418	✔
Sara A. Juntunen, Administrator, ect., et al., Plaintiffs vs. Green Tokai Co., et al., Defendant	In The Court Common Pleas Montgomery County, Ohio	Case Number: 2002-cv-07224	✔
IMO Industries, Inc., Plaintiff -against- Transamerica Corporation, TIG Insurance Company, et al., Defendants	Superior Court of New Jersey, Law Division Civil Part, Mercer County	Docket No.: L-2140-03	✔
Joseph LaPointe, Plaintiff vs. 3M Company, et al., Defendant	State Of Rhode Osland and Providence Plantations Superior Court	C.A. NO. 06-2418	✔
Franz, Losch and Maria Losch Plaintiffs vs. A.W. Chesterton, Inc. et al., Defendant	In The Superior Count Of The State Of California In And For The County Of Alameda	No. RG-07-311994	✔
Vickie Stillmunkes Plaintiff, vs International Flavors and Fragrances, Inc. et al., Defendant	In The United States District Court For The Northern District of Iowa Cedar Rapids Division	Case No. 1:04-CV-00085-EJM	✔
Willard E. Bartel and David C. Peebles Administrators For The Estate Of Charles, Wille, Deseased Plaintiff v. A-C Product Liability Trust et al., Defendants	Untied States District Court For The Northern District Of Ohio Western Division	Case No. 1:98CV12997	✔

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Case Style	Court	Cause Number	Deposition
Charles P. Rich Plaintiffs vs. A-C Products Liability et al., Defendant	In The United States District Court Northern District of Ohio Western Division	Case No. 1:98CV14094	✔
James R. O'Neill and Mary O'Neill, Plaintiff vs. American Oil Company, et al., Defendant	In The District Court Harris County, Texas 11th Judicial District	Cause No. 07-2589-EI	✔
Amanollah Shahabi and Mahin Shahabi Plaintiffs v. A.W. Chesterton Company et al., Defendants	In The Superior Court Of The State Of California In The County Of Los Angeles	BC 379 085	✔
Jefferson Riley Plaintiff v. Caterpillar Defendant	In The Circuit Court For Baltimore City	Case No.: 24-x-06-000753	✔
Bernice Walker, et al. Plaintiff v. Givaudan Flavors Corp., et al., Defendants	In The Court OfCommon Pleas Hamilton County, Ohio	Case No. A0700446	✔
Doris Rita Buffone Jambon, Plaintiff vs. Asbestos Defendants; et. al.,	Civil District Court, Parish of Orleans, State of Louisiana	Case No. 07-7826	✔
Lynda Daly and Michael Daly, her husband , Plaintiffs vs. Arvinmertor, Inc., et al., Defendants	In The Circuit Court Of The 17th Judicial Circuit In And For Broward County, Florida	Case No. 07-19211	✔
Jimmy D. Bohannon and Connie S. Bohannon Plaintiffs vs. Ametek, Inc. , et al., Defendants	In The District Court 11th Judicial District Harris County, Texas	Case No. 42334	✔
Gary Perry and Patrica M. Perry Plaintiffs vs. Armstrong International, Inc. et al. Defendants	In The Circuit Court For Knox County, Tennessee	Case No. 1-390-07	✔
Jerry Blaylock, et al., Plaintiffs vs. Sigma-Aldrich corporation, et al., Defendants	In The Circuit Court Of The City Of St. Louis State of Missouri	Case No. 052-10421	✔
Robert B. Oakley and irene Oakley, Plaintiffs vs. Air Products and Chemicals Inc.et al., Defendants	In The United States district Court For The Eastern District of Texas marshall Division	Case No. 2:07-CV-351	✔
Dennis Anderson, et al., Plaintiffs v. ACandS, Inc., et al., Defendants	In The Circuit Court For Baltimore City, Maryland	Case No. 24X08000056	✔

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Case Style	Court	Cause Number	Deposition
James Robert Prough and Margaret Prough v. Allis Chalmers Corporation Product Liability Trust et al., Defendants	Superior Court Of The State of California For The County Of Los Angeles	Case No. 389423	✔
Warren Lester, et al., Plaintiffs v. Exxon Mobil Corporation	Civil District Count Parish of Orleans State of Louisiana	Case No. 2002-19657	✔
Denton E. Crull and Joyce A. Crull Plaintiffs, v. Velan Valves	Superior Court Of The State Of California For The County Of Alameda Court Of Unlimited Jurisdiction	Case No. RG 08404667	✔

ATTACHMENT III

Table 1: Benzene Dermal Flux Data for Various Liquid Mixtures Containing Variable Benzene Levels

Table I: Benzene Dermal Flux Data for Various Liquid Mixtures Containing Variable Benzene Levels

Reference	Liquid Mixture	Benzene Conc.	Flux (mg/cm^2-hr)	*In vivo / in vitro*	Species & # subjects	Exposure Description	Comments
Hanke et al. 1961	Neat benzene	100 %	0.4	*in vivo*	Human forearm, n=10	Occluded. Exposure under watch glass	Benzene vapor
Fiserova-Bergerova 1989	Neat benzene	100 %	0.19		Rat		Flux value taken from Tsuruta, 1982
Blank et al. 1985	Gasoline	2% and reported flux normalized for 5%	0.062	*in vitro*	Human Abdomen	Autopsy skin – partial thickness. Exposure occluded. Glass diffusion chambers tightly capped. Flux values normalized for concentration	Stratum corneum was dried over Dririte when it was used for determining patrician coefficients.
Blank et al. 1985	Hexadecane	5% (v/v)	0.047	*in vitro*	Human Abdomen	Autopsy skin – partial thickness. Exposure occluded. Glass diffusion chambers tightly capped. Flux values normalized for concentration	Different flux values reported for pure benzene, benzene vapor, and
Blank et al. 1985	Hexane	5% (v/v)	0.105	*in vitro*	Human Abdomen	Autopsy skin – partial thickness. Exposure occluded. Glass diffusion chambers tightly capped. Flux values normalized for concentration	
Susten et al. 1985	Naphtha Distillate (rubber solvent)	0.5% (v/v) 0.14%	0.011 (calculated, not reported in original paper)	*in vivo*	mice Hairless mid-dorsal back n=12	Semi-occluded - stainless steel skin-depot attached to the skin. Mice were anesthetized with carbon dioxide.	rubber solvent: largely comprised of C4-C7 aliphatic hydrocarbons and a small percentage of aromatics including benzene (0.09%), toluene (5.7%), and xylenes (0.4%).
Susten et al. 1985	Neat Benzene	100%		*in vivo*	mice Hairless mid-dorsal back n=7	Semi-occluded - stainless steel skin-depot attached to the skin. Mice were anesthetized with carbon dioxide.	Percent penetration reported as 0.89 and 0.88%
Blank et al. 1985	Isooctane	5% (v/v)	0.187	*in vitro*	Human Abdomen	Autopsy skin – partial thickness. Exposure occluded. Glass diffusion chambers tightly capped. Flux values normalized for concentration	
Adami et al. 2006	Gasoline	0.74% 0.39% 1.06%	0.00271 0.00180 0.00147	*in vitro*	Human		
Loden, 1986	Neat benzene	100 %	0.099	*in vitro*	Human	Skin bathed in benzene at 5 mls/hour	
Franz 1982	Neat benzene	100 %	0.25	*in vitro*	Human	Split thickness abdominal skin from autopsy	

Reference	Liquid Mixture	Benzene Conc.	Flux (mg/cm^2-hr)	*In vivo / in vitro*	Species & # subjects	Exposure Description	Comments
McDougal et al. 1990	Neat benzene	100 %		*in vivo*	Rat - n=6	whole body in exposure chambers – no inhalation exposure	Permeability constant reported 0.152 cm/hr
Nakai at al. 1997		15-50 mcg/L_{H2O}		*in vitro*	Human Abdomen & breast	Tissue donated from elective surgeries. Samples in circulating pool	Permeability constant reported 0.14 cm/hr
Maibach & Anjo 1981		100 % 0.35 %		*in vivo*	Monkey	Multiple exposure scenarios including single and repeated does, and single exposures to intact and damaged skin.	
Arfsten et al. 2006	Mix of oils & isoparafinic hydrocarbons			*in vivo*	Humans Mice Rats Pigs		
Boman and Maibach 2000	n-butanol Toluene			*in vitro*	Human n=4	Split thickness skin from autopsy. Flow through penetration evaporation cells	
Modjtahedi & Maibach 2008	Neat benzene	100%		*in vivo*	Human n=4	Single exposure to intact skin. No inhalation exposure. Skin open to air: palmar exposure (fume hood) and Forearm in open air.	

ATTACHMENT IV

Oil Spill Calculations Using Dr. Nicas's Box Model

ATTACHMENT IV

Oil Spill Calculations Using Dr. Nicas's Box Model

Dimensions of box – 32' x 32' x 5' high

Average air speed in knots from 1984-2001 at Buoy BURL1 in South Pass = 11.8 knots

11.8 knots = 1195 fpm

Air flow entering the box at one end at 1195 fpm multiplied by the surface area of the side of the box equals the volumetric flow rate:

32 feet x 5 feet x 1195 feet per minute = 191,200 cubic feet per minute (cfm) or
5,414 cubic meters per minute.

Dr. Nicas assumed that 1% of the available mass of benzene in the spilled crude oil containing 0.3% benzene is evaporated rapidly. That would equate to:

(50 gal.) x (3,785 mL/gal) x (0.003) x (880 mg/mL) x (0.01) = 4,996 mg of benzene

EPI's calculation assumed that 4,996 mg of benzene evaporated every minute. Using the formula of:

$$\text{Concentration} = \frac{\text{generation rate}}{\text{Volumetric flow rate}} = \frac{4{,}996 \text{ mg/minute}}{5{,}414 \text{ cubic meters per minute}} = 0.92 \text{ mg/m3}$$

$$0.92 \text{ mg/m3} \times \frac{1 \text{ ppm}}{3.19 \text{ mg/m3}} = 0.29 \text{ ppm}$$

ATTACHMENT V

Historical Occupational Exposure Limits for Benzene

Attachment V
Historical Occupational Exposure Limits for Benzene

Year	TLV-History		OSHA Regulations			Additional Comments
	8-hr TWA	STEL	8-hr	15 min	10 min (ceiling)	
1946	100 ppm					MAC
1947	50 ppm					MAC
1948	35 ppm					
1957	25 ppm					
1963	25 ppm - C					Skin and ceiling value
1971			10 ppm		25 ppm [a] 50 ppm	[a] Maximum (10 minutes duration)
1977	10 ppm		1 ppm*			TLV A2; skin. *ETS that was set aside by U.S. Supreme Court
1978						TLV - Skin Notation Withdrawn
1978	10 ppm					A2
1980		25 ppm				
1987						TLV – STEL removed
1988			1 ppm	5 ppm		
1997-present	0.5 ppm	2.5 ppm				A1; Skin